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truly launch a new industry, Eclipse must efficiently produce airplanes in volume. To reduce the rivet count, Raburn turned to friction stir welding, a machine process in which a special tool with a protruding pin is pressed against one of two pieces of material to be joined. The rotating tool moves along the aluminum, creating frictional heat

EXCLUSIVE FIRST LOOK

Eclipse 500 debuts

The world's first look at this revolutionary new very light jet

BY THOMAS B. HAINES

I pushed firmly on the brakes as the pair of Pratt & Whitneys behind me quickly spooled up to maximum thrust. At brake release, the Eclipse 500 thundered down the runway, pushing me back into the seat. As 94 knots scrolled by on the electronic airspeed indicator, I gave the side stick a gentle tug and the airplane rotated off the pavement, leaving the vast majority of Albuquerque International Sunport's 13,800-foot-long Runway 8 still ahead of us.

As I write this it all sounds rather mundane: Another jet takes off. However, as the first nonemployee to fly the all-new Eclipse, I was a little anxious. While officially an FAA conforming aircraft, this is still an airplane very much in development. And if I was anxious, I can only imagine the feelings of Terry Tomeny, director of flight-test engineering, sitting in the right seat, and the team of engineers and technicians back at the flight-test center monitoring—quite literally—our every move through the telemetry system. It was as if I were dating their daughter.

Houston, we have a...solution

There are no shortages of opinions about the very-light-jet (VLJ) market and the airplanes in development to fill it. There are even arguments about whether the market exists, or will exist by next year when Eclipse, Cessna, and Adam expect to begin delivering VLJs. And among those projects, none has attracted as much attention as Eclipse and its controversial leader, Vern Raburn, who has been called both brash and brilliant.

In fact, he's both. He will brashly tell you why his airplane will be first to market, at the lowest cost, delivering the most value. Unlike most airframe chief executive officers, this one can tell you the number of circuit breakers in the airplane (two conventional and 127 electronic) and the moment-to-moment status of every aspect of the project from avionics maturity to the number of cycles expected out of a set of brake pads, to the square footage of the regional service centers the company will build (as he likes to say, "We're not building an airplane; we're building a company").

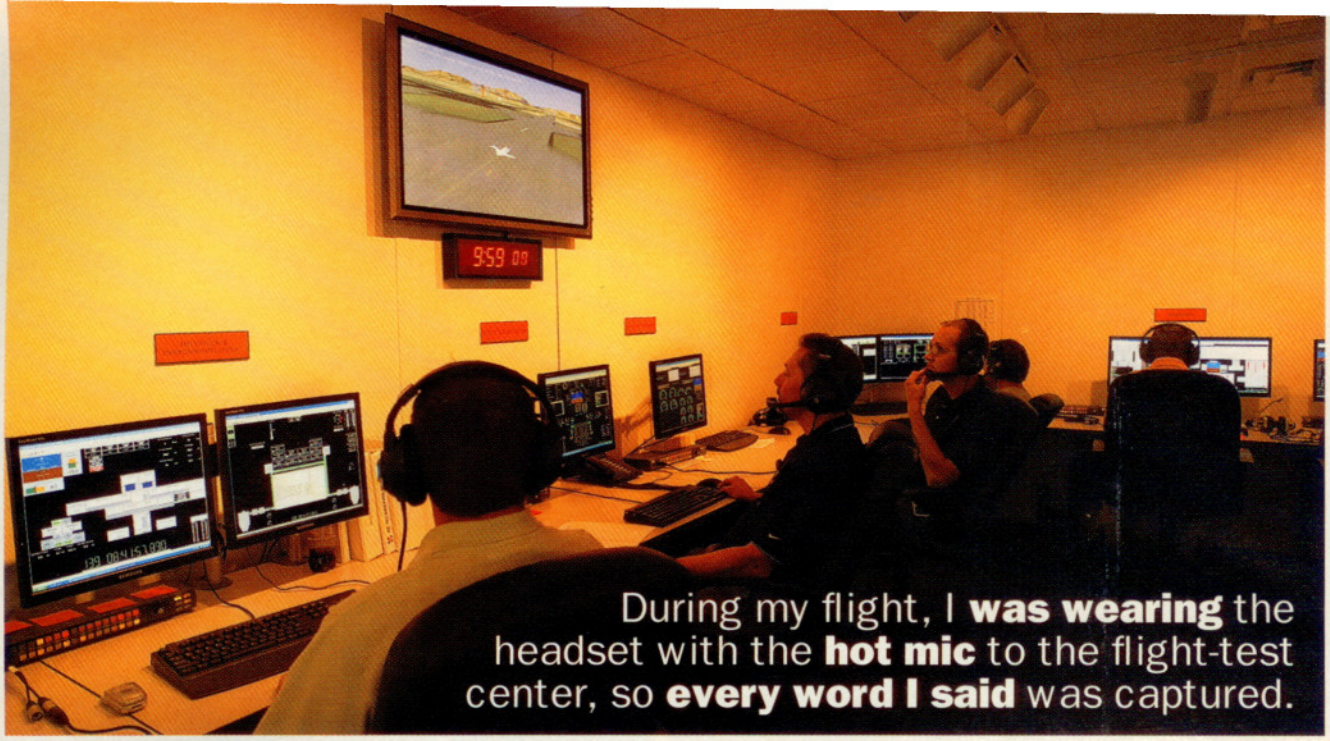
Giving credit where credit is due, the VLJ concept probably wouldn't exist today if it weren't for Raburn, a former Microsoft executive with a "get on board or get out of my way" approach to business. Some will argue that Williams International fostered the VLJ market in an effort to build an outlet for its line of small jet engines. But it wasn't until Raburn got on board that the concept gained momentum. To test its thinking, Williams developed a concept airplane called the V-Jet that later morphed into something called "Pronto." Raburn established Eclipse Aviation in 1998 with a vision of refining the VLJ concept, hoping to redefine air transportation by dramatically improving the economics of private jet travel. Raburn partnered with Williams and created the Eclipse 500, a small five- to six-place jet powered by a pair of Williams engines each producing 770 pounds static thrust (lbst).

The Eclipse-Williams marriage failed when the Williams EJ22 engines could not deliver the thrust necessary to propel the Eclipse 500. The very public divorce led Eclipse to Pratt & Whitney, which had been considering a line of

PHOTOGRAPHY BY MIKE FIZER

new small turbines. The resulting PW610F engines generating 900 lbst power today's 500.

In support of the Eclipse company vision Raburn has quite brilliantly put together a remarkable team of talent that is quickly maturing the Eclipse 500 design—the small jet that is a bit of an enigma. For example, the aluminum construction is quite conventional, except for the many "friction stir welded" pieces. Raburn wanted a low-risk airplane built out of conventional materials, but he recognized the expense and time it takes to build an aluminum airplane using conventional rivets. With a business plan demanding hundreds to thousands of units being built a year to achieve the price point necessary to truly launch a new industry, Eclipse must efficiently produce airplanes in volume. To reduce the rivet count, Raburn turned to friction stir welding, a machine process in which a special tool with a protruding pin is pressed against one of two pieces of material to be joined. The rotating tool moves along the aluminum, creating frictional heat that softens the metal and causes it to bond to the adjoining piece. The process, which is used in the construction of Boeing Delta rockets and by the shipbuilding industry, produces a stronger, lighter bond than riveting. The process does not completely eliminate riveting on the 500, but it does dramatically reduce the manufacturing time and expense.



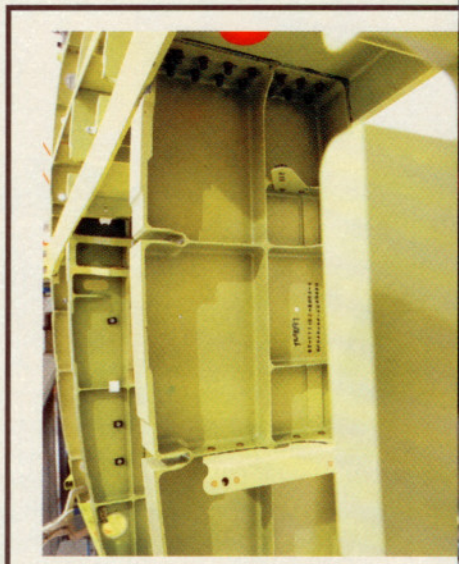
And while the aluminum wing ribs, for example, may look like conventional pressed ribs, they are, in fact, machined from large aluminum billets, which increases strength, assures tighter tolerances, and saves time.

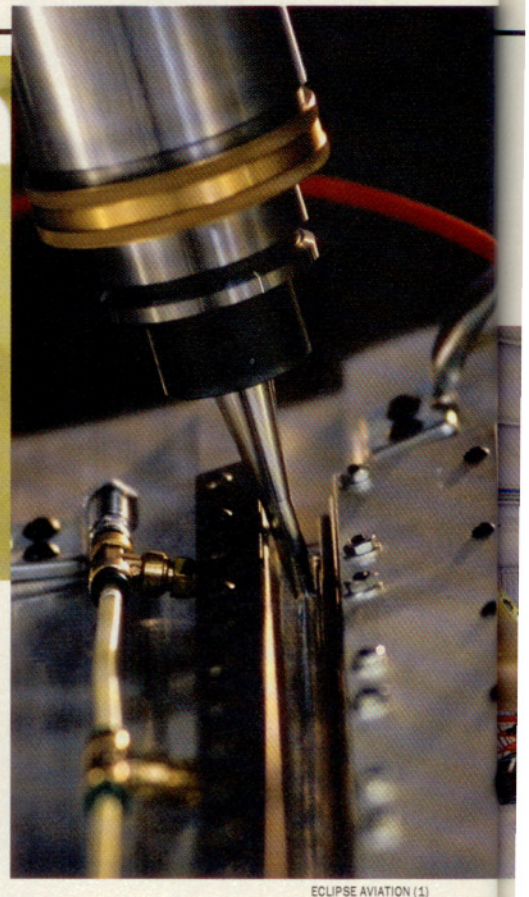
Like the aluminum airframe, other parts of the aircraft are quite conventional—there are no antiskid brakes, for example, and the flight control system uses tried-and-true cables, pushrods, and pulleys (although the cockpit features side-stick controllers).

Inside, however, Raburn's technology background from companies such as Microsoft, Lotus, and Symantec, for example, begins to show up. The engines are driven by a full authority digital engine control (FADEC) and will include autothrottles to help reduce pilot workload. Priced at $1.3 million, the 500 will be the only airplane under $20 million to include autothrottles. Also breaking new ground, the 500 includes the Avio Total Aircraft Integration System, basically a software operating system for the entire airplane. Avio is the brain that runs every system in the airplane from environmental to electrical to FADEC.

The pilot interface to Avio is through Avidyne displays. The Avidyne system includes a pair of 10.4-inch-diagonal primary flight displays (PFDs) oriented in a portrait format and a horizontal multifunction display (MFD). Dual air data attitude and heading reference systems (ADAHRS) are standard, one driving the pilot's PFD and the other driving both the copilot's PFD and a smaller PFD depiction in the upper-left corner of the multifunction display. There are no conventional backup instruments. Eclipse believes the redundancy of the dual ADAHRS and reversionary modes of the Avidyne displays plus a sophisticated electrical system that uses four independent sources—two generators and two batteries—to power five buses should mitigate concerns about a complete failure of the electronics. The electronic power distribution system (EPDS) is predicted to be reliable to 10 to the minus-9 level. In other words, if all of the lights go out, you're having a very, very unlucky day.

The Avidyne system in the Eclipse is second generation, integrating the digital VHF navigation and communication radios into the panel. Current-genera-





ECLIPSE AVIATION (1)

tion Avidyne FlightMax Entegra systems use a conventional radio stack. Pilots can access Avio and the communications and navigation system using either the buttons and knobs around the displays or the computer keyboards that pop out from beneath each yoke.

Avio's job is to act as a virtual copilot, according to Matt Brown, Avio product manager. Eclipse believes that Avio's total aircraft integration concept will excel at three things: enhancing safety through reduced pilot workload; increasing aircraft reliability; and reducing acquisition and operating costs.

To enhance safety, Avio presents synoptics on the MFD that help with everything from checklists to emergencies. Think of synoptics as electronic depictions of aircraft systems. If Avio senses a problem with a fuel valve, for example, it will issue a caution or alert, depending on the severity of the condition. Once the pilot acknowledges the alert by hitting the master caution/warning button, Avio displays the fuel system schematic on the MFD, showing the fault. Using the buttons surrounding the display, the pilot can attempt to solve the problem, perhaps by resetting the fuel valve. Access to the electronic circuit breakers associated with the faulty system is only a keystroke away. During critical phases of flight, Avio suppresses unnecessary messages that might distract the pilot.

In an electrical problem, Avio is capable of automatic load shedding, turning off systems that are not needed that may be contributing to the fault. Avio uses what Eclipse calls "mode-less data flow." All redundant systems are working constantly, so if one fails, the other picks up the load or processes without the pilot having to switch modes; in fact, in most cases the pilot may not even know a problem occurred until Avio shows a message through the crew alerting system (CAS), which is a message window on the MFD. Like FADEC, autothrottles, and synoptics, CAS is a concept adapted from the airliner and business-jet world. Raburn believes that through modern electronics such safety systems can be adapted to all levels of GA aircraft.

Brown says Avio will increase reliability and reduce cost through its ability to track, record, and alert maintenance anomalies. Each Eclipse airplane will come equipped with a data recorder that captures about 10 megabytes of data every flight hour. The data will be stored on an on-board 2-gigabyte drive—about 200 flight hours' worth of storage. The pilot or maintenance technician downloads the data through a port on the panel onto a USB drive for transmission to Eclipse. The company has in place 14 terabytes of storage for its current systems and future customers. It will analyze the data on an ongoing basis, allowing it to proactively deal with potential maintenance issues and adapt changes to aircraft in production. Critical failures, such as an in-flight engine shutdown, will be communicated directly to Eclipse through an on-board satellite-based datalink system within 30 seconds.

Fly early, fly often

While individual pilots will be the primary Eclipse customers for the first year or two, in the end Raburn and company think the majority of 500s and future Eclipse models will be purchased by air-taxi and fleet operators. VLJ believers suggest that this new generation of light jets can lower per-mile seat costs to the point—around $1 per seat-mile—that customers will be lining up to fly point to point on VLJs rather than using the airlines' inefficient hub-and-spoke system.

Eclipse mills entire bulkheads (far left, top) out of solid aluminum billets. A friction-stir-welding head joins two pieces of aluminum (middle left). The "welds" are visible in the bottom-left image. Two function and reliability airplanes under construction in late May (immediate left) will be flying this summer. Pratt & Whitney uses an aggressively shaped fan blade on the new PW610F engine (above left). The Integration Test Lab (above) allows engineers to quickly ferret out system integration problems.

Each Eclipse airplane will come **equipped with a data recorder** that **captures about 10 megabytes** of data every flight hour.

Eclipse believes its per-seat-mile cost will be 89 cents.

Because of rising prices for raw materials and the higher costs of the larger Pratt & Whitney engines, Eclipse recently raised the price of an Eclipse 500 from $1.15 million to $1.295 million in 2000 dollars, which equates to about $1.421 million at the end of 2004. At that price, the 500 costs about one-fourth the price of a conventional light jet.

While the 500 will be an inexpensive jet, as jets go, it will not be a "cheap" jet, says Raburn. The company is spending a considerable amount of effort to build in reliability and ways to make the aircraft easy to maintain, something that fleet operators demand. System components are being placed in easy-to-access areas, such as the engine pylons. The "hell hole," the empennage area that traditionally houses many jet systems (so named by technicians who have to service the systems), is relatively free of system components and those that are there are easily accessed. "Every component that can fail is designed to be replaced in four hours or less," says Raburn, the same service level that Boeing promises its airline customers.

As of mid-May, the company had garnered more than 2,200 orders, two-thirds of them multiple orders from fleet customers. All are secured with nonrefundable deposits.

The walkaround

Tomeny joined Eclipse as director of flight-test engineering this year after leaving Lockheed Martin, where he worked on the F–22 and various F–16 flight-test programs. While much of his flying is military oriented, he and his wife are enthusiastic general aviation pilots and owners of a Piper Cherokee 140.

As we walk around the airplane he points out how simple the 500 is relative to other jets. The landing gear is actuated by electric motors, no hydraulics. The emergency gear extension procedure is to pull a handle in the floor of the cockpit, causing the gear to free-fall. The main landing gear is of trailing-link design. Trailing-link gear tends to absorb even the worst landings with aplomb, making the pilot look good. The gear can be extended at speeds up to 250 KIAS; once the gear is down the 500 can be accelerated up to the V_{MO} of 285 KIAS, allowing for easily managed descents. Eclipse is considering using the main gear as the speed brake. Lifting a speed brake handle next to the thrust levers will drop the main gear down about 10 degrees, increasing drag for faster descents.

The fuel system is equally simple. Fuel is pumped from the main wing tank on each side into a sump tank on each side. The sump tanks feed the engines. What appear to be tip tanks are, in fact, more like wing extensions, increasing wing-

Eclipse 500 guaranteed price and performance

Price (June 2000 economics)
$1,295,000

Max cruise speed*
375 kt (+/–2.5%)

Stall speed
67 kt (+/–4%)

Range, 4 occupants**
1,280 nm (+/–5%)

Useful load
2,250 lb

* at 4,950 lb, standard conditions
** at high-speed cruise, NBAA IFR 100-nm alternate, one 200-lb pilot, and three 170-lb passengers

ECLIPSE AVIATION (2)

span. The wing is wet to the tip. The upswept tips contain only about six gallons of fuel each. Most of the space is an expansion area for fuel vapors. The aircraft is fueled through ports on the top of the tip tanks. Eclipse briefly considered the idea of single-point refueling, which allows for a fast fill-up, but introduces weight and complexity. As it is, Raburn estimates with a hose to each tank, the aircraft can be filled in about 10 minutes. The 500 carries 1,540 pounds of fuel, which is about 230 gallons. Extremely accurate quantity sensors mean the pilot can actually rely on the ship's gauges rather than a watch for fuel information.

All lights on the exterior except the landing lights are LEDs, light-emitting diodes, which prove to be not only bright but also extremely durable, lasting many thousands of hours. Interior lights are also mostly LEDs, used because they are reliable and don't generate much heat. The electrically actuated flaps, which extend 12 inches inboard of the wing roots to underneath the fuselage, are similar to a Fowler-type design in that they move aft, increasing area, and then down. Takeoff flaps of 15 degrees can be put out at 200 KIAS; approach and landing flaps of 30 and 37.5 degrees can be deployed at 150 KIAS. The flaps are effective, too. With full flaps, approach speeds can be as low as 85 to 90 knots. I flew two approaches—an ILS to a touch and go and then a normal pattern followed by a full stop. In both cases, I slowed the airplane to about 90 knots roughly one mile from the runway. Crossing the threshold, the speed was down to 85 knots—approach speeds common for an airplane such as a Beechcraft Bonanza. Throughout the approach, the airplane handled very conventionally. Even in turns at those speeds, there was no mushiness in the controls or a sense that the airplane was near a stall. While most larger jets and turboprops are flown onto the runway with only enough flare to keep the nose tire from hitting first, I flared the 500 the way one might a lighter piston airplane. Because I flared too high, the first landing was a bit of an arrival, putting the trailing-link gear to the test. The second landing was much better. A similar attitude allowed the main gear to neatly roll onto the pavement. I then lowered the nose gradually. Thanks to the very stable slow-speed handling characteristics and landing manners more like a piston airplane, pilots moving up to the 500 from a high-performance piston single, for example, will have no problem managing the airplane on approaches, takeoff, and landing.

Eclipse snapshot

- December 31, 2004, first flight of Pratt & Whitney-powered Eclipse 500.
- Three test airplanes flying as of mid-May.
- $398 million of equity and debt funding.
- 2,200-plus orders.
- DayJet, an on-demand jet service, placed 239 orders with 70 options.
- 190,000 square feet under roof.
- 61,000 square feet under construction.
- 410-plus employees.
- FAA certification expected first-quarter 2006.
- Major partners
  - Fuji Heavy Industries, of Japan—wing assemblies
  - Pratt & Whitney Canada—engines
  - Avidyne—avionics, electronic flight information system
  - Meggitt Avionics—autopilot
  - Others from England, France, Chile, Italy.

Tuck it in close

About three minutes after my initial takeoff in the 500, I was tucking the airplane up near a B36TC Bonanza carrying *AOPA Pilot* Senior Photographer Mike Fizer. Flying an airplane for a photo mission in which you are expected to fly in formation a few yards away from another airplane is a good way to test its handling characteristics. Thankfully the early morning air over the desert near Eclipse's Albuquerque headquarters was smooth. Spool-up speed on jet engines can be an issue when flying formation because many small power adjustments are needed to keep the airplane right where the photographer wants it. The lagged response time of many jet engines can make that difficult. However, the pair of small Pratt & Whitney engines responded quickly to even small changes.

Because of restrictions in the flight-test airspace, we were limited during our flight to 17,000 feet. Eclipse flies most tests at 25,000 feet. I was flying N504EA, the third of the three flight-test airplanes in use as of mid-May. Two additional airplanes are for static and ground testing. Two more airplanes are for function and reliability testing (F&R in flight-test parlance); they should be flying within a few weeks. Eclipse engineers consider those two airplanes "beta" ships because they plan to put more than 1,000 hours each on them before the first customer 500 is delivered in the second quarter of 2006. Although only about 200 hours of F&R testing are required, Eclipse wants to find out where any reliability problems might lurk before it begins delivering airplanes.

Combined with piston-single-type approach speeds, the trailing-link main landing gear promises a smooth arrival.

SPECSHEET

Eclipse 500

Current base price: $1.295 million (2000 dollars)

Specifications

Powerplants	2 Pratt & Whitney PW610F, 900 lbst each
Length	33 ft 1 in
Height	11 ft
Wingspan	37 ft 3 in
Seats	5-6, including cockpit
Cabin length	12 ft 4 in
Cabin width	4 ft 8 in
Cabin height	4 ft 2 in
Empty weight	3,390 lb
Max ramp weight	5,680 lb
Max gross weight	5,680 lb
Useful load	2,250 lb
Payload w/full fuel	710 lb
Max takeoff weight	5,640 lb
Max landing weight	5,360 lb
Fuel capacity	230 gal (1,540 lb)

Performance

Takeoff distance, ground roll	2,155 ft
Rate of climb, sea level	2,990 fpm
Single-engine ROC, sea level	888 fpm
Max cruise speed	375 KTAS
Range, NBAA IFR	1,280 nm
Range, 45-minute reserve	1,395 nm
Max operating altitude	41,000 ft
Single-engine service ceiling	25,000 ft
Landing distance, ground roll	2,040 ft

Limiting and Recommended Airspeeds

V_{FE} (max flap extended)	250 KIAS
V_{LE} (max gear extended)	285 KIAS
V_{LO} (max gear operating)	250 KIAS
V_{MO}/M_{MO}	285 KIAS/Mach 0.64
V_{SO} (stall, in landing configuration)	67 KIAS

For more information, contact Eclipse Aviation Corp., 2503 Clark Carr Loop Southeast, Albuquerque, New Mexico 87106; 505/245-7555; fax 505/241-8800; www.eclipseaviation.com.

The Eclipse 500 is not yet certificated. All specifications are based on manufacturer's calculations. All performance figures are based on standard day, standard atmosphere, sea level, gross weight conditions unless otherwise noted.

A united front: Eclipse taps airline expertise for training

Eclipse Aviation President and Chief Executive Officer Vern Raburn says that "safety is an ecosystem of interrelated parts." Everything impacts and is a part of safety, he explains, the aircraft, the pilot, and aircraft operations. The company has done what it can to build a safe airplane, but the biggest unknown in the ecosystem is the pilot.

The emergence of the very-light-jet (VLJ) market has led many to speculate that VLJ pilots, many of whom will not have flown a jet or any airplane in the flight levels before, will create serious safety issues, especially as they operate these airplanes single-pilot. In an effort to address those concerns and bring Eclipse pilots up to speed as quickly as possible, Eclipse Aviation has partnered with airline training giant United Services, a division of United Airlines, to run the Eclipse 500 training program.

Using the vast training resources at the United training center in Denver, Eclipse and United instructors will tailor a program for Eclipse pilots. Each Eclipse sold includes a full training program and ultimately a type rating for those who qualify. Unlike traditional airline and corporate flight-training programs, which are geared toward professional pilots who fly nearly every day, the Eclipse training will concentrate on transitioning less experienced pilots into a jet. A major portion of the training will concentrate on improving pilot management skills and judgment, which are seen as major weaknesses for general aviation pilots. As Raburn espouses, "There must be only one level of proficiency for all pilots. Just getting by is not good enough."

The training provided by United will be mission oriented, sometimes called "scenario based," meaning situations that unfold in the simulator will be ones that might actually occur during a flight instead of simply overloading a pilot with unrealistic multiple major system malfunctions just to see how he performs.

Prior to reporting to Denver for training, Eclipse pilots will be expected to have instrument and multiengine ratings and be proficient in instrument flight. In addition, they must complete through home study Eclipse's five-part computer-based training program on jet operations and high-altitude flying.

Once at Denver, the pilots will initially be given an evaluation flight in one of United's Boeing 737 simulators trimmed down to act more like a simpler airplane. Eclipse has ordered six 500 simulators for delivery in 2006 that may take on this role later. Pilots who don't pass the evaluation will be sent home for additional proficiency training on their own. Otherwise, pilots can expect to spend about seven days learning to fly an Eclipse and earning a type rating. Upset recovery training in Eclipse's L-39 jet trainer also will be offered, for an additional $995, as will high-altitude physiological training for those who have not been through such a program.

Those who cannot complete the training program will be given their deposits back or given the option of hiring a professional pilot.

Even those who pass the type-rating course but don't have previous jet time will be required to spend some number of hours flying with an experienced mentor pilot trained by Eclipse in what the company calls the "supervised operating experience." Once the initial training is complete, Raburn believes much more valuable learning can occur during every flight with the mentor. "The analogy is learning to play golf on a driving range versus learning on a course with a coach," he says.

Eclipse and United will also offer recurrent training programs, which will be required every six months for those in the mentor program and annually for others.

Additional type-rating courses for noncustomers will be available for about $7,000. —*TBH*

In addition, the company is building a highly accelerated life testing (HALT) lab in an effort to uncover any system weaknesses early. The HALT lab is basically a big meat locker that can be cooled and heated from zero degrees Celsius to 55 degrees C. Cabinets inside the lab will be capable of exposing systems to temperatures as cold as minus 55 degrees C, typical of high-altitude operations.

Whenever a system anomaly crops up either during ground testing or in flight, technicians turn to the Integration Test Lab to try to find out why. The ITL is like a 500 without the airframe. All of the systems are set up and running, controlled from a cockpit-type setting. Moving the flap lever, for example, actuates a flap motor. Turn on the windshield heat and the windshield heats up. The engineers say the ITL has been invaluable in pulling all of the system operations into Avio and making them play together.

Because of Eclipse's sophisticated flight-test operation, technicians can often solve a system problem even before the test airplane returns to base. Each flight-test aircraft is equipped with thousands of sensors that capture data for all systems and measure all sorts of flight conditions, including G loads. The data are sent via telemetry to Eclipse's tracking antenna on a tall pole next to its hangar. The antenna can track a test airplane as far away as 100 miles. Each airplane sends back about 4 gigabytes of data an hour across as many as 4,000 parameters. During a test flight, eight technicians work at stations equipped with one or more computer displays where they can monitor every aspect of the flight. If a certain test result is not correct, the flight-test director can ask the flight crew to repeat it, saving valuable time. If it weren't for the telemetry system, the data would be stored on the aircraft and couldn't be processed until after the flight. A system anomaly leads the technicians to the Integration Test Lab where they can often come up with a fix on the fly and relay it back to the flight crew or at least have it ready for the next flight.

Eclipse relies on tried-and-true pneumatic boots for wing deicing. Bleed air provides anti-ice protection to the engine inlets.

During my flight, I was wearing the headset with the hot mic to the flight-test center, so every word I said was captured. The technicians were paying attention because during the debriefing after the flight, they quizzed me on everything I said, anxious for feedback from someone other than their own test pilots. I probably disappointed them because although I've flown more than 100 models of airplanes over the years, I certainly don't consider myself a test pilot.

They need not worry, though, because the airplane they have so carefully crafted over the past five years is just what they intend it to be: a simple, inexpensive jet that most any pilot with a few days of concentrated training could safely fly and enjoy. Many pilots moving up from less sophisticated airplanes and not used to flying in the flight levels will need additional mentoring, but no competent pilot will have difficulty mastering the 500's flight characteristics. AOPA

i Links to additional information about Eclipse Aviation may be found on AOPA Online (www.aopa.org/pilot/links.shtml).

E-mail the author at thomas.haines@aopa.org.


Beechcraft
N3864K
Sierra